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ABSTRACT

A 21-year longitudinal study (1955-1976) was conducted on the educational and professional careers of men who specialized in engineering in Ontario, Canada. Data was collected from schools, universities, employers, and the subjects themselves. In 1956, 683 males and no females enrolled in university engineering courses. In general, the engineering students were a superior group. Of the 683, 65% (444) graduated and the other 35% withdrew without earning a degree. In most cases, withdrawal followed academic failure. The withdrawals were older than the graduates, were more likely to be living away from home, and had fathers who were not in high status occupations. Six or seven years after graduation, 69% of the graduates were practicing engineering in Ontario. Those who did not become engineers in Ontario were practicing the profession outside Ontario or had entered other professions. Information was collected on employment during the academic year, during summer vacations, and after graduation. After approximately fourteen years of working, the average graduate had had three employers. Almost half the respondents had earned no degree other than the bachelor's. Of those who had obtained advanced degrees, 40% had chosen an engineering related field, almost 25% had obtained a master's in business administration, and 10% had obtained doctorates. Four out of five respondents had undertaken some formal education since graduation, although not necessarily for credit. Shortly after graduation, the courses chosen were highly technical; later, they showed ever-widening interests. (LMS)

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Minneapolis, Minnesota, U.S.A.

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TWENTY-ONE YEARS IN THE LIVES OF 444 MEN

Dormer Ellis

Canada

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TWENTY-ONE YEARS IN THE LIVES OF 444 MEN

Abstract

Some findings of a longitudinal research project in which the educational and professional careers of individuals were followed from 1955 until 1976 are presented in this paper. The methodology whereby the researchers were successful in keeping track of the subjects for such a lengthy period is also discussed. This research has provided factual information about a number of questions concerning pre-service and continuing education of a professional group. Although the research subjects all began their engineering studies in Ontario, Canada, many are currently living and working elsewhere in Canada, in the U.S.A. or overseas.

Statistical procedures identified personal characteristics, family background and school factors related to progress through the undergraduate programmes, and contrasted the characteristics of repeaters with those of engineering students who withdrew. It being discovered that many graduates of engineering programmes never practise the profession of engineering, a special study was made of the characteristics of those who enter other occupations and their reasons for doing so.

As the careers of the research subjects have been followed year by year, information has been accumulated about their continuing education, formal and informal, and about their career patterns. It was noted that engineers seek different types of continuing education at various stages in their professional lives.

Only by means of a longitudinal study which attempts to follow *every* member of a defined group year after year, regardless of geographical mobility and occupational change, can accurate information be obtained about what really does become of students who enrol in professional programmes.

Introduction

The longitudinal project to which this paper pertains grew out of a large-scale, educational research activity undertaken in Ontario more than twenty years ago.

Ontario is the second largest of the ten Canadian provinces, with an area larger than that of Germany, France and the Netherlands combined. About eight million Canadians live in Ontario. Many of them derive their livelihood from mining or manufacturing. Ontario is fortunate in having mineral resources and abundant water power so that industry flourishes and the general standard of living is quite high. The population is entirely literate as education from age six to sixteen has been free and compulsory for several generations.

The profession of engineering ranks high in public esteem and the designation 'professional engineer' is restricted by law to persons who are members of the Association of Professional Engineers of Ontario. The usual way to become a member is to spend seventeen years in formal education culminating in an engineering degree from an Ontario university, followed by another two years of practical experience in appropriate employment.

The Atkinson Studies of the Utilization of Student Resources

There had been a dearth of factual information about the aptitudes, interests, aspirations and plans of Ontario boys and girls as well as a lack of statistical data concerning the further formal education and employment experiences of secondary school and university graduates. Such information as was available had been obtained, of necessity, from cross-sectional, sample surveys rather than from long-term investigations of the career patterns of total student populations. Until the 1950's, educational research in Canada was still in its infancy.

Ontario was very fortunate when, in 1955, the Atkinson Charitable Foundation provided a grant to enable educational researchers at the University of Toronto to make an extended study of a complete cohort of Ontario Grade 13 students. Grade 13 is the final year of secondary education and is required for admission to Ontario universities. As far as is known, the boys and girls who happened to be in Grade 13 during the 1955-56 academic year were not unique in any respect. All 9573 of them were designated as research subjects for a province-wide study of the utilization of student resources which continued for a number of years.

Collection of Basic Data

When the students were in Grade 13, a great deal of background information was obtained about each one of them. The secondary schools made their files available for research purposes and the academic history of each student was copied from these records. Groups of teachers rated each research subject on certain personality traits such as co-operation with teachers and fellow students, reliability and industry in school work. Also, each student

completed a lengthy questionnaire about himself and his family. The questions included the educational attainments of parents and siblings, the father's occupation, and the parents' educational aspirations for their children. The students also described their own ambitions and plans for future education and employment. As an integral part of the research project, standardized tests of academic aptitude and achievement were administered. The marks earned on the final examinations in Grade 13 were also collected by the researchers.

During the next few years, when many of the research subjects were attending universities, schools of nursing, technological institutes and teachers' colleges, these post-secondary educational institutions co-operated with the researchers by making available the results of their annual examinations. Of course, the engineering faculties in the universities were no exception and so the researchers were able to keep track of the academic success of each engineering undergraduate as he proceeded through the four-year programme. Employers were also helpful in tracing former students who had entered employment.

Publications Concerning Atkinson Research Subjects[1]

During the decade 1957-67, a series of thirteen research reports was published. Some concern the Atkinson research subjects as a whole; for example, Report No. 1 by W. G. Fleming is entitled 'Background and Personality Factors Associated with Educational and Occupational Plans and Careers of Ontario Grade 13 Students'. Other reports in the series are devoted entirely to one or another of the 'destination groups'. This term refers to the occupational or educational choice of the student immediately after his Grade 13 year. An example is Report No. 13 by Dormer Ellis et al which focusses on those research subjects who enrolled in teachers' colleges. Generally speaking, the reports about specific destination groups compared the students in a particular group with their former Grade 13 classmates and also described what had happened to the members of that particular destination group during their first few years after graduation from secondary school. By 1962, the data-collecting phase of the Atkinson Study of the Utilization of Student Resources had been completed. The findings of the research, as originally designed and funded by the Atkinson Charitable Foundation, had all been published by 1967.

Longitudinal Studies Undertaken

The educational researchers had become particularly interested in two of the destination groups, one being the engineering undergraduates, and decided to embark on longitudinal studies of these groups. The research techniques employed have included both the collection of information about the research subjects from a number of sources and occasional contact with the subjects themselves to solicit their opinions on various topics.

Characteristics of Students Who Enrolled in Engineering Programmes

The 1955-56 Ontario Grade 13 population of 9573 individuals had a sex ratio of three males to two females. In September 1956, 683 of the boys and no girls enrolled in university courses in Engineering. Because statistical tests had shown that Grade 13 boys were quite different from the girls on a number of personal, family and academic characteristics, it was decided to compare the engineering destination group with other boys rather than with Grade 13 students as a whole. Tests of statistical significance such as the 't' test and the chi-square test were applied where appropriate and one per cent was taken as the level of statistical significance.

What type of student chose engineering as an undergraduate programme? As a group, the engineering students came from smaller families, had better-educated parents, lived in larger communities, were younger, had higher academic aptitude scores, and had higher secondary school marks than did their Grade 13 male classmates. The engineering group also had a higher proportion of its members rated as 'very superior' in leadership and initiative than would be expected just by chance. In general, it was found that the students who enrolled in engineering courses were a superior group of Grade 13 graduates.

As well as comparing the engineering students with the total group of Grade 13 males, the researchers compared them with certain other destination groups. The group that the engineering students resembled most closely was that of men who undertook university courses in Honour Arts or Honour Science and the group from which they differed to the greatest extent was that of young men who became elementary-school teachers. It was also found that the engineering students differed greatly from the male Grade 13 students who enrolled in non-university courses in technology. This latter group tended to be older, have parents of lower educational level, have fewer brothers and sisters with university education, and have lower secondary school marks than was true of Grade 13 males in general. The unexpected difference between the personal and family characteristics of engineering and technology students might be related to the relative newness of technology courses in Ontario in 1956 whereas Engineering as a university discipline had been established for over half a century.

Academic Success in Undergraduate Programmes

How did the 683 engineering students make out at university? Sixty-five per cent of them graduated from engineering courses and the other 35 per cent withdrew without earning a degree. Because a 35 per cent drop-out seems rather wasteful of human and financial resources, a study was made of the students who withdrew.

Why did they withdraw? The answer depends on whether you question representatives of the universities or the students themselves! In most cases, withdrawal followed academic failure. However, the students were likely to attribute both their failure and their subsequent withdrawal to a non-academic cause such as poor health, or financial problems resulting from marriage or parenthood.

Did the students who withdrew differ statistically from the students who graduated? Indeed, they did! For example, the average age at university entrance was nearly four months younger for the successful engineering students than for the withdrawals; this is, of course, a reflection of the relative incidence of grade repetition in elementary and secondary school. Also, withdrawals were more likely to be living away from home than were successful students. A higher percentage of withdrawals had fathers who were not in the professional or managerial categories of occupational status.

A follow-up study was made of the withdrawals from engineering programmes. It is rather surprising to find that the young men who withdrew from engineering courses did not enter employment in related fields. When they were contacted three or four years after leaving their engineering studies, they were found to be in such occupations as selling real estate, working as a bank teller, operating a clothing store, and so on. Only nine of the 239 engineering withdrawals enrolled in technology courses and only two of the nine graduated as technologists. The researchers were interested to learn that very few of the withdrawals from engineering courses expressed any bitterness about the time and money they had invested in engineering studies which they did not complete. The vast majority said that they would want their sons to go to university even if they were not able to graduate. Perhaps the embarrassment and frustration of failure fade and, after a few years, only the more pleasant memories of one's university experience remain.

Although the engineering programmes at Ontario universities are four-year programmes, not all who graduated spent only four years on their undergraduate work. About one in five spent more than four years at university before graduating. A statistical study was made of the repeaters. Comparisons were made between repeaters and withdrawals. Repeaters differed from withdrawals mainly on family characteristics. They were more likely to come from families in which university graduation was the normal expectation for the sons. Of the 93 repeaters in the engineering group, 80 repeated only one undergraduate year and the other 13 repeated more than once. Because multiple repetition is in fact contrary to the regulations of some engineering faculties, the case histories of the multiple repeaters were carefully examined. They had all moved from one university to another. The most extreme case was that of a student who attended three universities for a total of seven consecutive years before earning a bachelor's degree. He came from a well-to-do family of seven brothers and sisters, every one of whom graduated from university. This again suggests the influence of family expectation on whether a failing student withdraws from university or repeats his year.

Registration as Professional Engineers

In order to practise as a professional engineer in Ontario, one must be licensed by the Association of Professional Engineers of the Province of Ontario. Both academic achievement and practical experience are prerequisite to registration with the A.P.E.O. Very few young men have had enough practical experience in industry either

prior to university entrance or during undergraduate vacation periods to enable them to meet the A.P.E.O. admission requirements immediately upon graduation; a year or two usually elapses before the graduate of an engineering course applies for registration as a professional engineer. This delay is apparent in the histories of the research subjects. Although 351 of the 444 engineering graduates were awarded their degrees in 1960 and most of the others received theirs in 1961, the membership list of the A.P.E.O. for 1961 showed only 96 of the research subjects.

An interim research report of the longitudinal research project was completed in 1968 and presented at the annual meeting of the Engineering Institute of Canada.[2] It indicated that 308 of the 444 graduates--that is 69 per cent--were licensed to practise the profession of engineering by that time. Counts of research subjects listed in the A.P.E.O. directories of 1972 and 1975 confirm that graduates who do not seek and obtain registration as professional engineers within six or seven years of university graduation are unlikely to do so later on. For the past decade, the number has hovered around three hundred, the most recent count being 299.

Engineering Graduates Who Don't Become Ontario Professional Engineers

As about thirty per cent of the graduates have never sought membership in the A.P.E.O. and so are not entitled to practise the profession of engineering in Ontario, the question of what has happened to them naturally arises. It was found that they form two distinct groups; those practising the profession outside Ontario and those who have entered other professions. The geographical mobility of engineering graduates is impressive. As the procedures of the longitudinal research project include locating each research subject at least once every two years, the researchers have been in correspondence with engineers in many provinces of Canada, the United States, Great Britain, Hong Kong, Australia, etc. Graduate engineers living and working in other provinces or in other countries have usually obtained registration with the appropriate association.

Among the engineering graduates who were not practising as engineers, the most common profession was that of secondary school teaching. However, several other professions were represented. Upon graduating from an engineering course, one man re-entered university as a law student; he became a lawyer specializing in patent cases. Another man studied physiology and entered the field of medical electronics. Several graduate engineers undertook post-graduate studies in pure rather than applied science and became physicists or chemists.

In the statistical analysis, comparisons were made between those practising as professional engineers (regardless of whether they were employed in Ontario or elsewhere) and the engineering graduates engaged in other professions. Comparison criteria included personal characteristics, family background, types of schools attended, and academic achievement in secondary school and in university work. These factors were known from the basic data of the Atkinson studies. The two groups were not found to differ significantly on any criteria other than academic achievement. Both in secondary school and in

university, the differences between the marks of engineering graduates who became professional engineers and the marks of those who entered other occupations are statistically significant. As an example of the research findings, consider the graduates' average marks in the final year of undergraduate work. Although the mean average mark of the 'professional engineering' group and the mean average mark of the 'other professions' group are almost identical, the distributions of the average marks are quite different. With rare exceptions, the members of the 'other professions' group had average marks that placed them in either the lowest fifth or the highest fifth of the cases. Almost all of the graduates whose final year average marks were in the middle sixty per cent of the cases were in the 'professional engineering' group but those whose marks were in the highest twenty per cent and those whose marks were in the lowest twenty per cent were less likely to practise as professional engineers. What is the explanation of this enigma? One must examine the post-graduate histories of engineering graduates. Many of those who were highly successful as undergraduates enrolled as full-time graduate students, often in the pure rather than the applied sciences; after earning additional degrees, they obtained employment in research work as scientists rather than professional engineers. On the other hand, certificate and degree courses in business administration attracted mainly engineering graduates of lesser academic achievement. Engineering graduates who went directly into a one-year programme to prepare for teaching in the secondary schools were drawn mainly from the lowest fifth of the engineering graduates.

Employment Experiences

In 1964, each of the 444 engineering graduates was asked to complete a four-page questionnaire. The results of this survey were published in Engineering Careers in Canada[3] for the information of engineering students and their potential employers. The questionnaire included items about employment experiences during undergraduate years and subsequent to graduation. Both factual information and expressions of opinion were sought.

Part-time employment during the academic term was not considered to be feasible for engineering students because of their heavy load of lectures and laboratory work, but practical experience during vacation periods was highly recommended. Over 80 per cent of the respondents indicated that the value of summer work was not in technical knowledge gained but in a deeper understanding of the world of work. Typical comments were: "I had no idea of the monotony of a machine operator's day", "If you keep your eyes and ears open, you learn a great deal about labour and management problems", and "The foreman couldn't care less about the 'A' you got in Electrical Theory—he just wants to know how you can be so slow at splicing cables". Several of the respondents spoke highly of certain professional engineers who had taken a fatherly interest in them and helped them to make the most of the learning experiences provided by summer employment.

Employment After Graduation

Of the engineering graduates who went into employment immediately after graduation, less than a fifth returned to their summer employers.

By far the most common reason given by the respondents for accepting a particular position immediately after graduation was that the salary was higher than that available for other positions. The median length of time spent with the first employer after graduation was only eighteen months. Why did they move? The modal reason given for changing employers was "to obtain a more challenging position or a position involving more responsibility". Salary was mentioned as important in only five per cent of the changes. Is it that engineering graduates are less mercenary after a year or two of industrial employment than they are immediately after university graduation?

The 1974 Employment Survey

A study conducted in 1974 as part of this longitudinal research project concerned the number of employers the research subjects had had since graduation and the length of time spent in the employ of each one. This study was limited to those research subjects who were entitled to practise engineering in Ontario. The number of employers (in approximately fourteen years of working experience) ranged from one to six, the most common being three. A common pattern was a year or two with a first employer, then about five years with a second employer before accepting employment with a third. When asked why they had moved from the second to the third employer, salary was mentioned less frequently than was opportunity for future promotion or the opportunity to escape from what had become a routine job. Data were obtained from published materials and supplemented with information from employers and, through telephone interviews, from the research subjects themselves.

Continuing Formal Education of Engineering Graduates

Preliminary information about the continuing formal education of engineering graduates was obtained from certain questions included in the 1964 survey of the 444 research subjects who had earned a bachelor's degree in engineering. From time to time, further data on this topic had become available concerning those graduates who were practising the profession of engineering in Ontario because the annual A.P.E.O. directories list members' post-graduate degrees and indicate when and where they were earned. The results of tabulations made in 1967 and in 1972 are included in a paper prepared for a conference on engineering education held in Indiana in 1973.[4] The researchers suspected, however, that not all post-graduate degrees had been reported to the professional association because this information is not required for registration purposes. Also, little was known about the continuing formal education of those research subjects who were engaged in engineering work outside Ontario or who were employed in other types of work. Therefore, the focus of the final survey of the engineering graduates, conducted in the spring of 1976, was their continuing formal education. All research subjects were to be included, irrespective of their present type of employment or geographical location.

The success of the research team in keeping track of the subjects of this longitudinal study is exemplified by the fact that up-to-date addresses are known for 417 of the 444 engineering graduates. Over a period of twenty years, contact has been lost with only five per cent

of the research subjects. (It is noted with regret that five of the men are now deceased.) The co-operative attitude of the subjects themselves is illustrated by the response to the mailed questionnaire. Of the 417 questionnaires sent out last spring, 399 have been completed and returned to the researchers. Of course, the majority were returned promply from subjects living in Ontario but others have come from more distant parts of Canada, the United States, Europe, Africa and Asia.

Additional Degrees

Of the 399 respondents to the 1976 survey, almost half reported that they had earned no degree other than the bachelor's degree in engineering about fifteen years ago. Of those who had obtained one or more additional degrees, forty per cent had done so in a field directly related to their undergraduate programme. The median length of time between a bachelor's and a master's degree in engineering was four years. It was observed that engineering graduates who do not begin post-graduate studies during the first five or six years after obtaining the bachelor's degree are unlikely to do so later on. Next to the master's degree in an engineering discipline, the most common post-graduate degree was a master's in business administration. This type of degree was earned by almost a quarter of the research subjects who had obtained an additional degree. Other types of degrees earned by research subjects included bachelor's degrees in general arts, commerce and education as well as master's degrees in divinity, arts and education. Six of the graduate engineers had obtained degrees in law. Degrees at the doctoral level, not necessarily in an engineering discipline were reported by ten per cent of those who had obtained additional degrees.

Certificates and Diplomas

The 1976 survey of the continuing formal education of the research subjects also sought information about courses they had taken which led, not to a degree, but to some certificate or diploma. Such programmes were found to be especially popular among engineering graduates who were not engaged in the practise of engineering. Many had obtained a certificate or diploma in education before entering the teaching profession, a few had non-degree qualifications in such fields as computer programming or journalism. The certificate programmes that appeared to be the most popular among research subjects licensed to practise engineering in Ontario or elsewhere were those pertaining to business administration or management techniques.

Continuing Education

In recent years, articles in technical publications and session themes at engineering conferences have stressed the growing importance of continuing education for professional engineers. It is reassuring to note that four out of five of the subjects of this longitudinal research project report that they have undertaken some formal education since graduation, although not necessarily for academic credit. Correspondence courses, evening courses, and short intensive courses were mentioned as well as courses provided by employers during regular working hours. In some cases the courses were sponsored by engineering associations and in other cases by employers or universities.

It is interesting to observe that the length of time that has

elapsed since graduation increases, the type of course desired by the engineering graduate gradually changes. The courses that were most popular soon after graduation were highly technical, specialized courses in the person's own branch of engineering and were usually undertaken for academic credit. Five years later when many of the men had assumed some managerial as well as technical responsibilities, part-time studies in management techniques, industrial psychology and economics were frequently reported. Courses concerning computers continued to be popular but the nature of the chosen courses had changed from practical instruction in how to write a particular computer language to more philosophical considerations such as the influence of computer technology on modern society. By 1971, some ten years after they had received their engineering degree, the research subjects showed ever-widening interests. Participation in purely technical courses had declined but courses in public speaking, current affairs, oral French and social science subjects were frequently mentioned.

Tests of Statistical Significance

Statistical tests were carried out to find on what factors those engineering graduates who did continue their formal education were different from those who did not. There was some indication that those who were most successful academically at both the secondary school and university level were more likely to continue taking courses, but the relationship was not a strong one. It was rather interesting to find that the man's marital status and number of children was unrelated to the likelihood of his continuing his formal education on a part-time basis after graduation. However, the responses to questionnaire items revealed a belief on the part of many of the subjects that such was the case. Some men who had not undertaken any courses since graduation explained that their responsibilities as husbands and fathers kept them too busy to do so. On the other hand, some men commented that their growing family responsibilities necessitated their keeping up-to-date through continuing formal education so that they could move as soon as possible into better-paying managerial positions.

Engineers Turned Educators

An entirely-unexpected finding of this longitudinal study of an entire cohort of engineering graduates is the movement of persons trained for the engineering profession into the field of Education. In 1967 it was noted that 8 per cent of the 444 engineering graduates were employed in Education and by 1972 the percentage had risen to 15. It has remained constant since that time. Which ones became educators and why? At what levels in the educational system do they teach?

Graduate Engineers Teaching in Post-Secondary Institutions

It is entirely understandable that some of the research subjects would have obtained employment as teachers of future engineers and technologists. Where else would universities and technological institutes get suitable staff other than from the ranks of graduates of engineering programmes? There are research subjects currently teaching in post-secondary institutions in Alberta, British Columbia and Guyana as well as in Ontario. These engineers-turned-

educators have excellent undergraduate records, post-graduate education often to the doctoral level and also some practical experience in industry.

Graduate Engineers Teaching in Ontario Schools

None of the research subjects has ever taught in the elementary grades. However, ten per cent of them are currently teaching in the secondary schools of the province. Their subjects of instruction are general science, mathematics, physics and chemistry. Those who became teachers almost immediately after graduating from engineering usually came from the lowest quarter of graduates on the criterion of final average mark. (It should be recalled, however, that the total group was a very select one!) Those who entered the field of secondary school teaching after a few years in industry usually did so in response to some personal employment crisis such as being discharged because a department or company was closing down, being overlooked for promotion, or a personality conflict with a superior. It is rather interesting to note that most graduate engineers who expected to teach only temporarily have found that they enjoy the work very much and have decided to continue in a teaching career. A Master of Education thesis done at the University of Toronto in 1975 made a detailed study of the ten per cent of the longitudinal research subjects who had become secondary-school teachers.[5]

Comment

In a continuous effort to improve their status, influence and opportunities for service, the members of a profession must obviously take an interest in research into the capacities, attitudes, interests and background of those who enter that profession. They must attempt to see the image of the profession as it appears in the eyes of young people at the beginning of the period of training and as they proceed towards eventual full professional competence. Longitudinal studies of complete cohorts of undergraduates can provide much useful information, particularly if they are carried out over extended periods of time and great care is taken to keep in touch with all the research subjects.

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[1] Atkinson Study of Utilization of Student Resources. Reports 1 to 13. 1957-67. The Ontario Institute for Studies in Education, Toronto, Canada. W. G. Fleming et al.

[2] "Engineering Students—Who Are They and What Happens to Them?" An address to the 82nd annual meeting of The Engineering Institute of Canada, Halifax, N.S., 1968. M. Dormer Ellis

[3] "Engineering Students/Les étudiants en génie". Engineering Careers in Canada, 1969 and 1970 editions. M. Dormer Ellis, pp. 5-8.

[4] "Twenty Years in the Lives of Three Hundred Men". A Paper prepared for the 'Frontiers in Education' conference, West Lafayette, Indiana. April 1973.

[5] "A Study in Occupational Mobility Determinants of Atkinson Engineering Graduates from Engineering to Secondary School Teaching". Master of Education thesis, University of Toronto, 1975. Paul F. McMackin.